ORM PTO-1390
REV. 11-2000)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
3606-0120P

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)
NEW

NTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP00/07119	July 24, 2000	July 30, 1999

ITLE OF INVENTION
METHOD AND SYSTEM FOR DYNAIMIC ALLOCATION OF RADIO CHANNELS IN DIGITAL TELECOMMUNICATION NETWORKS

APPLICANT(S) FOR DO/EO/US
MARGHERITA, Fulvio; PAROLARI, Sergio

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39 (1).
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau). WO 01/10155
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is transmitted herewith.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4)
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 20. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98, Form PTO-1449(s), and International Search Report (PCT/ISA/210) with 1 cited document(s).
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information:
   1.) PCT Substitute Claims Letter w/ PCT/IPEA/409 and amended sheets
   2.) Three (3) sheets of Formal Drawings

Rec'd PCT/PTO 30 JAN 2002

U.S. APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
NEW	PCT/EP00/07119	3606-0120P

		CALCULATIONS	PTO USE ONLY
1. ☒ The following fees are submitted: **BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5):** Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO........	**$1,040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO........	**$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO............	**$740.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)............	**$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)..................	**$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =		$ 890.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).		$ 130.00	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	CALCULATIONS	PTO USE ONLY
Total Claims	16 - 20 =	0	X $18.00	$ 0	
Independent Claims	1 - 3 =	0	X $84.00	$ 0	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)		Yes	+ $280.00	$ 280.00	
			TOTAL OF ABOVE CALCULATIONS =	$ 1300.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				$ 0	
			SUBTOTAL =	$ 1300.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐20 ☐30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$ 0	
			TOTAL NATIONAL FEE =	$ 1300.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 0	
			TOTAL FEES ENCLOSED =	$ 1300.00	
				Amount to be: refunded	$
				charged	$

a. ☒ A check in the amount of $ 1300.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account. No. ___________ in the amount of $_______ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 02-2448.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

Send all correspondence to:
Birch, Stewart, Kolasch & Birch, LLP or Customer No. 2292
P.O. Box 747
Falls Church, VA 22040-0747
(703) 205-8000

Date: January 30, 2002

By ______________
Michael K. Mutter, #29,680

/cqc

10048215 10/048215
JC13 Rec'd PCT/PTO 30 JAN 2002

PATENT
3606-0120P

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant: MARGHERITA, Fulvio et al.

Int'l. Appl. No.: PCT/EP00/07119

Appl. No.: New Group:

Filed: January 30, 2002 Examiner:

For: METHOD AND SYSTEM FOR DYNAMIC ALLOCATION OF RADIO CHANNELS IN DIGITAL TELECOMMUNICATION NETWORKS

PRELIMINARY AMENDMENT

BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, DC 20231

January 30, 2002

Sir:

The following Preliminary Amendments and Remarks are respectfully submitted in connection with the above-identified application.

AMENDMENTS

IN THE SPECIFICATION:

Please amend the specification as follows:

Before line 1, insert --This application is the national phase under 35 U.S.C. § 371 of PCT International Application No. PCT/EP00/07119 which has an International filing date of July 24, 2000, which designated the United States of America and was published in English.--

Docket No. 3606-0120P

IN THE CLAIMS:

Please amend the claims as follows:

2. (Amended) Method according to claim 1, characterized in that at each request for a communication service (Sx) the services employing the same number (Rx) of channels (Ci) of the requested service (Sx) are reordered in such a way that the attenuation (PLx) increases with priority values (Pi).

3. (Amended) Method according to claim 1 or 2, characterized in that it includes an allocation algorithm including the following operational steps:

- first searching, starting from timeslots (Ti) with highest priority values (Pi), a timeslot (Tx) having a number of free channels (Ci) equal to the number (Rx) of channels (Ci) of the requested service (Sx);
- second searching, starting from timeslots with priority values (Pi) higher than that of the timeslot (Tx) found with the first search, a communication service (Sy) having the same number (Rx) of allocated channels (Ci);
- comparing the path loss values of the signals of the requested communication service (Sx) and of communication service (Sy) found with the second search;

- allocating, according to the result of this comparison, one of these communication services (Sx, Sy) in the timeslot (Tx) having said number (Rx) of free channels (Ci).

4. (Amended) Method according to claim 3, characterized in that said algorithm is reiterated according to the result of said comparison between the attenuation values of the signals of the requested communication service (Sx) and of the communication service (Sy) found with the second search.

5. (Amended) Method according to claim 3, characterized in that it is searched, starting from timeslots with priority values (Pi) higher than that of the timeslot (Tx) found with this first search, the communication service (Sy) whose signals show the lower attenuation (PLm) among the communication services having the same number (Rx) of channels (Ci) allocated in the same timeslot (Tx).

6. (Amended) Method according to claim 1, characterized in that at each release of a communication service (Sx) are reordered according to increasing priority values (Pi) the services employing the same number (Rx) of channels (Ci) of the service released (Sx).

7. (Amended) Method according to claim 6, characterized in that it includes a release algorithm including the following

operational steps:

- third searching, among the timeslots with priority values (Pi) lower than that of the timeslot (Tx) of the released communication service (Sx), a timeslot (T) in which at least a communication service having the same number (Rx) of channels (Ci) of the communication service released (Sx) is allocated;
- allocating in the timeslot (Tx) of the released communication service (Sx) the communication service (Sy) characterised by the highest attenuation among all the services employing Rx channels (Ci) in the timeslot (T) found with the third search.

8. (Amended) Method according to claim 7, characterized in that said third searching and allocating steps of the release algorithm are performed as in the following:

- third searching, among the timeslots with priority values (Pi) lower than that of the timeslot (Tx) of the released communication service (Sx), a timeslot (T) in which at least a communication service employing a number of channels (Ci) lower than that of the communication service released (Sx) is allocated;
- allocating in the timeslot (Tx) of the released communication service (Sx) the communication service (Sy) characterised by a higher attenuation amongst all the services employing a number of channels (Ci) lower than that of the communication service released (Sx) and which are allocated in the timeslot (T) found with the third search.

10. (Amended) Method according to claim 1, characterized in that at each allocation and/or release of a service, the priority values (Pi) assigned to the timeslots (Ti) are re-calculated on the basis of the following formula:

$$Pi(k) = \lambda Pi(k-1) + (1-\lambda)s_i(k),$$

where k is the instant at which the service is allocated or released, $s_i(k)$ is a logic function returning a number between 0 and 1 on the basis of the negative or positive result, respectively, of these requests for connection services and λ is a memory factor included between 0 and 1.

11. (Amended) Method according to claim 10, characterized in that $s_i(k)$ is defined by the following formula:

$$s_i(k) = \frac{N_{free_i}(k)}{N_{\max} - N_{used_i}(k)};$$

in which $N_{free\ i}(k)$ is the number of channels Ci that can be allocated with a good quality in the timeslot i, N_{max} is the maximum number of channels available for each timeslot and $N_{used\ i}(k)$ is the number of channels presently already allocated in timeslot i.

12. (Amended) System for the dynamic allocation of radio channels (Ci) in digital telecommunication networks with time division duplex access, the system including at least one base

station (1) for the reception and transmission of radio signals associated to the radio channels (Ci) from/to a plurality of user equipment (2), the radio signals being divided in frames having pre-determined duration and each frame being divided into a pre-determined number of timeslots (Ti) which are assigned priority values (Pi) based on interference and/or quality measures of channels (Ci), each communication service (Sx) employing a particular number (Rx) of said channels (Ci) at a time, characterized in that said base station (1) includes means for the measurement of the path loss (PLx) of the signal with which said communication service (Sx) has been requested, as well as a control processor suitable to implement all the steps of the method according to claim 1.

Docket No. 3606-0120P

REMARKS

The specification has been amended to provide a cross-reference to the previously filed International Application.

The claims have been amended to delete improper multiple dependencies and to place the application into better form for examination. Entry of the above amendments is earnestly solicited. An early and favorable first action on the merits is earnestly solicited.

Attached hereto is a marked-up version of the changes made to the application by this Amendment.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

By ______________________

Michael K. Mutter, #29,680

P.O. Box 747
Falls Church, VA 22040-0747
(703) 205-8000

MKM/cqc
3606-0120P

Attachment: VERSION WITH MARKINGS TO SHOW CHANGES MADE

VERSION WITH MARKINGS TO SHOW CHANGES MADE

The claims have been amended as follows:

2. (Amended) Method according to [the previous claim]claim 1, characterized in that at each request for a communication service (Sx) the services employing the same number (Rx) of channels (Ci) of the requested service (Sx) are reordered in such a way that the attenuation (PLx) increases with priority values (Pi).

3. (Amended) Method according to [one of the previous claims]claim 1 or 2, characterized in that it includes an allocation algorithm including the following operational steps:

- first searching, starting from timeslots (Ti) with highest priority values (Pi), a timeslot (Tx) having a number of free channels (Ci) equal to the number (Rx) of channels (Ci) of the requested service (Sx);
- second searching, starting from timeslots with priority values (Pi) higher than that of the timeslot (Tx) found with the first search, a communication service (Sy) having the same number (Rx) of allocated channels (Ci);
- comparing the path loss values of the signals of the requested communication service (Sx) and of communication service (Sy) found with the second search;
- allocating, according to the result of this comparison, one of

these communication services (Sx, Sy) in the timeslot (Tx) having said number (Rx) of free channels (Ci).

4. (Amended) Method according to [the previous claim]claim 3, characterized in that said algorithm is reiterated according to the result of said comparison between the attenuation values of the signals of the requested communication service (Sx) and of the communication service (Sy) found with the second search.

5. (Amended) Method according to claim 3[or 4], characterized in that it is searched, starting from timeslots with priority values (Pi) higher than that of the timeslot (Tx) found with this first search, the communication service (Sy) whose signals show the lower attenuation (PLm) among the communication services having the same number (Rx) of channels (Ci) allocated in the same timeslot (Tx).

6. (Amended) Method according to [one of the previous claims]claim 1, characterized in that at each release of a communication service (Sx) are reordered according to increasing priority values (Pi) the services employing the same number (Rx) of channels (Ci) of the service released (Sx).

7. (Amended) Method according to [the previous claim]claim 6, characterized in that it includes a release algorithm including the following operational steps:

- third searching, among the timeslots with priority values (Pi) lower than that of the timeslot (Tx) of the released communication service (Sx), a timeslot (T) in which at least a communication service having the same number (Rx) of channels (Ci) of the communication service released (Sx) is allocated;
- allocating in the timeslot (Tx) of the released communication service (Sx) the communication service (Sy) characterized by the highest attenuation among all the services employing Rx channels (Ci) in the timeslot (T) found with the third search.

8. (Amended) Method according to [the previous claim]claim 7, characterized in that said third searching and allocating steps of the release algorithm are performed as in the following:

- third searching, among the timeslots with priority values (Pi) lower than that of the timeslot (Tx) of the released communication service (Sx), a timeslot (T) in which at least a communication service employing a number of channels (Ci) lower than that of the communication service released (Sx) is allocated;
- allocating in the timeslot (Tx) of the released communication service (Sx) the communication service (Sy) characterized by a higher attenuation amongst all the services employing a number of channels (Ci) lower than that of the communication service released (Sx) and which are allocated in the timeslot (T) found with the third search.

Docket No. 3606-0120P

10. (Amended) Method according to [one of the previous claims]claim 1, characterized in that at each allocation and/or release of a service, the priority values (Pi) assigned to the timeslots (Ti) are re-calculated on the basis of the following formula:

$$Pi(k) = \lambda Pi(k-1) + (1-\lambda)s_i(k),$$

where k is the instant at which the service is allocated or released, $s_i(k)$ is a logic function returning a number between 0 and 1 on the basis of the negative or positive result, respectively, of these requests for connection services and λ is a memory factor included between 0 and 1.

11. (Amended) Method according to [the previous claim]claim 10, characterized in that $s_i(k)$ is defined by the following formula:

$$s_i(k) = \frac{N_{free_i}(k)}{N_{\max} - N_{used_i}(k)};$$

in which $N_{free\ i}(k)$ is the number of channels Ci that can be allocated with a good quality in the timeslot i, N_{max} is the maximum number of channels available for each timeslot and $N_{used\ i}(k)$ is the number of channels presently already allocated in timeslot i.

12. (Amended) System for the dynamic allocation of radio channels (Ci) in digital telecommunication networks with time division duplex access, the system including at least one base

Docket No. 3606-0120P

station (1) for the reception and transmission of radio signals associated to the radio channels (Ci) from/to a plurality of user equipment (2), the radio signals being divided in frames having pre-determined duration and each frame being divided into a pre-determined number of timeslots (Ti) which are assigned priority values (Pi) based on interference and/or quality measures of channels (Ci), each communication service (Sx) employing a particular number (Rx) of said channels (Ci) at a time, characterized in that said base station (1) includes means for the measurement of the path loss (PLx) of the signal with which said communication service (Sx) has been requested, as well as a control processor suitable to implement all the steps of the method according to [one of the previous claims]claim 1.

(Rev. 11/13/01)

METHOD AND SYSTEM FOR THE DYNAMIC ALLOCATION OF RADIO CHANNELS IN DIGITAL TELECOMMUNICATION NETWORKS

Field of the Invention

The present invention relates to a method for the dynamic allocation of radio channels in digital telecommunication networks, in particular with time division duplex access or TDD (*Time Division Duplex*), such as for instance mobile telecommunication networks belonging to DECT or UMTS-TDD standards. The present invention relates also to a system implementing this method.

It is well known that in mobile telecommunication networks with TDD access, the transmission and reception of radio signals from and to the base stations do not occur at the same time, but are alternated in a continuous sequence of periods having pre-determined duration, each of them called *frame* and opportunely coded and identified by the system. In particular, each frame is divided into a pre-determined number of time intervals or *timeslots*, they too having pre-determined duration, part of which is destined to transmission and part to the reception of the signals from base station to user equipment. Each one of these timeslots can also be subdivided into a plurality of *codes* representing the elementary resources (channels) assigned in the communication.

At each communication service between a mobile unit and a base station one or more channels of a particular time slot are generally assigned, which contains at most Nmax channels, according to the requested transmission speed.

Background art

Patent application WO 98 24258 A, assignee TELEFONAKTIEBOLAGET LM ERICSSON, discloses an "ADAPTIVE CHANNEL ADAPTATION METHOD FOR MULTI-SLOT, MULTI-CARRIER COMMUNICATION SYSTEM. The claim 1 testually recites:

" 1. In a communications system in which communications from a link transmitter to a link receiver are transmitted pursuant to a multi-slot communication scheme over subset of a set of a plurality of channels available to a link, a method of allocating channels for communications on a link, said method comprising the steps of:

- allocating a plurality of channels from said set to provide said subset;
- measuring a received signal on each channel of said set;
- determining if at least one unused channel exists in said set that is more preferred for use on said link than a channel of said subset; and

– reconfiguring said subset in response to an affirmative determination".

The measures performed on the second step are periodic measures of the quality C/I of the channels within the subset and the interference level of all the N available channels of the set. For the aim of best evaluating the condition of the channels also the level of multipath fading is measured upon channels upon which signals are transmitted downlink to the mobile station. A mobile station can avails itself from all the M channels of the subset except for the channels already in use to other mobile stations in the cell. The criteria adopted to allot a sorted channel to a service requester is that to allocate the least interfered channel placed at the top of the list to the first user which requests to be served and the remaining channels to the successive requesters ordered in the time. Channel allocation doesn't request any gender of measure on the requesting signal and doesn't involve any rearrangement of the channel priorities. The main drawback of the allocation method disclosed in the cited patent application is the absence of any suitable criterion to submit the allocation of a channel to the distance from the service requester to the Base Station, so that could reasonably happen that the nearest user receives the least interfered channel and the farthest user receives the most interfered channel, although intermediate situations are most realistic. As known, in any radiomobile system the ability to have channels with good quality depends on the skill to transmit with low power. The underlined drawback of the allocation mechanism doesn't allow a generalized power reduction overall in the system, in consequence of that the spectral efficiency is not improved.

Another example of a dynamic channel allocation procedure based on priority values Pi calculated for each timeslot is disclosed in the article by Y. Furuya and Y. Akaiwa under the title "Channel Segregation, A distributed Adaptive Channel Allocation Scheme for Mobile Communication Systems", Second Nordic Seminar on digital Land Mobile Radio Communication, 14-16 October 1986", pp 311-315. In the procedure of this second citation a control processor of the base station performs at each service request, a calculation of the priority values Pi on the basis of interference and/or quality measures of the channels, so that the timeslots available for the allocation of channels result only those whose priority value is higher than a given pre-set threshold value Pt. The calculation of priority values Pi of each timeslot after k service requests is generally made through the following iterative formula:

$$Pi(k) = \frac{Ns_i(k)}{k} = \frac{\sum_{a=1}^{k} s_i(a)}{k} = \frac{k-1}{k} Pi(k-1) + \frac{s_i(k)}{k};$$

where k is the number of connection service requests from the moment of system starting, $Ns_i(k)$ is the number of successful connections and $s_i(k)$ is a logic function returning 0 or 1 on the basis of the negative or positive result of the connection, respectively.

Observing such formula, it can be noticed that at starting, with small k values, the calculation of priority values very quickly adapts to the network characteristics, but results slowed when k values increase, therefore the above mentioned method known for the allocation of channels shows a high risk for connection losses in case the network traffic distribution suddenly changes, for instance when number of connection service requests occur, concentrated in time.

Summary and scope of the invention

Object of the present invention is therefore that to give a method for the dynamic allocation of channels which is free from this drawback, as well as a system implementing this method. Said object is attained with a method and a system whose main characteristics are specified in claims 1 and 12, respectively, while additional characteristics which are believed to be novel are specified in the appended claims.

The quality of channels allocated through the method according to the present invention is generally better compared to that of the channels allocated through the known methods. In fact, at equal number of allocated channels, the services with signals having higher attenuation values or "path loss" are allocated in timeslots having higher priority values, so that the allocated channels can be shared in the different timeslots in the best way according to the quality of the relevant signals. The peculiar allocation mechanism of the present invention allows to lower the power requirements for those users which need higher transmission power to counterbalance the pathloss due to their geographical penalty. The general power reduction further reduces the distance of reuse and increases the spectral efficiency consequently.

Another advantage of the present invention due to the allocation mechanism is the minimization of the so-called near-far effect, improving the performance of data detection in UMTS systems.

Furthermore, the method according to the present invention results much more rapid than the known methods, since a partial re-ordering of channels allocated in the different timeslots is made, that is, at each service requests, only the services employing the same number of channels of the requested service are re-ordered.

Another advantage of the method according to the present invention is represented by the use of a new kind of formula for the calculation of priority values which, contrarily to the above mentioned formula of the known type, enables to discretionary adjust the

system adaptation speed to the contingent situation of the network traffic, that is to the interference and/or quality variations of the channels.

A further advantage of the method according to the present invention is represented by the fact that said allocation and release algorithms can be structured in such a way to give preference, if necessary, to the services employing a low or high number of channels.

Brief description of figures

The present invention together with further advantages and characteristics thereof may be understood by those skilled in the art making reference to the following detailed description taken in conjunction with the accompanying drawings in which:

- figure 1 shows a partial block diagram of a system implementing the method according to the present invention;
- figure 2 shows a flow chart of an allocation algorithm of an embodiment of the method according to the present invention; and
- figure 3 shows a flow chart of a release algorithm of an embodiment of the method according to the present invention.

Detailed description of a preferred embodiment of the invention

Making reference to figure 1, it can be noticed that a system implementing the method according to the present invention includes in a known way, a plurality of base stations 1 belonging to a digital telecommunication network with time division duplex access, such as for instance a mobile telecommunication network belonging to the UMTS standard, which communicate through radio signals with a plurality of user equipment 2. One or more channels Ci of a timeslot Ti are generally assigned to each communication service Si made by base stations 1 (only 8 timeslots Ti of communications originated by the user equipment 2 are shown in the figure, for representation simplicity). Furthermore, a univocal priority value Pi is assigned to each timeslot Ti which, however, can vary in time according to the result of a known formula of the type described above or of a new formula which shall be described here after. Said priority values Pi are based on interference and/or quality measures of communication channels Ci between base stations 1 and user equipment 2.

According to a preferred embodiment of the invention the interference and/or quality measures of channels are made measuring the "path loss", that is the attenuation of the signal transmitted by the user equipment 2. According to the invention, the communications with higher path loss are allocated in timeslots with higher priority Pi, that is in channels capable of ensuring a better transmission quality. On the contrary,

communications with lower "path loss" are allocated in timeslots with lower priority Pi, that is in channels capable of ensuring a lower quality.

Tentatively said situation has been represented in figure 1 where for each station 1 a first coverage area 3 and a second coverage area 4 are represented. In figure 1 it is assumed that users located in the coverage area 4 are more distant from the relevant base station 1 and therefore communications shall be reasonably characterised by a higher "path loss" (they shall therefore be assigned a timeslot having higher priority Pi), while the users in coverage area 3 are closer to the relevant base station 1 and therefore their communications shall be reasonably characterised by a lower "path loss" (they shall therefore be assigned a timeslot having lower priority Pi).

Now, making reference also to figure 2, we notice that an embodiment of the method according to the present invention includes an allocation algorithm, which is started for instance on the moment a mobile unit 2 requests a service Sx requiring the use of a given number Rx of channels Ci to a base station 1. The base station 1 measures the level and therefore the path loss PLx of the signal with which the mobile unit 2 has requested said service Sx on the receipt channel. On the basis of the path loss measured value PLx, the base station 1 attempts to allocate the Rx channels Ci in the timeslot having an increasing priority value Pi with the same attenuation PLx, in order that user equipment 2 transmitting signals having a high path loss use timeslots having a high priority value.

To this purpose, it is searched, starting from timeslots having higher priority values Pi, a timeslot Tx having Rx free channels Ci. If said timeslot Tx does not exist, the base station 1 refuses the requested service Sx to the mobile unit 2. If on the contrary said timeslot Tx is found, the base station 1 searches, if existing, a timeslot where at least a service employing Rx channels Ci is allocated among the timeslots with priority value Pi higher than that of the timeslot Tx. This search is made through a scanning based on a variable T cyclically decreased by one unit. If the variable T is zeroed, the requested service Sx is allocated in the timeslot Tx. If on the contrary a timeslot T is found where at least a service with Rx channels Ci is allocated a search is made among all the services employing Rx channels Ci and are in the same timeslot T, the service Sy showing the lower path loss PLm. At this point, the base station 1 compares the value of the lower path loss PLm found with that of the PLx path loss of the signal with which the mobile unit 2 has requested the service Sx to base station 1. If the PLx path loss value is lower than that of the PLm path loss, the requested service Sx is allocated in the timeslot Tx having Rx free channels Ci, otherwise it is allocated in the same the service Sy employing Rx channels Ci and showing the PLm path loss. In this

last case, since a service having Rx channels Ci in the timeslot T got free, the algorithm described up to now is reiterated starting from this last timeslot, which is then identified as timeslot Tx in the reiteration of the algorithm itself, that is Tx = T.

When the service Sx is released, for instance after the interruption of a communication between mobile unit 2 and base station 1 or due to the transfer of a communication between two base stations 1, it is possible to employ a release algorithm of essentially inverse type compared to the one described above to free the timeslots Ti with low priority values Pi.

Making reference to figure 3, we see that an embodiment of the method according to the present invention includes a release algorithm, which is started for instance on the moment at which a service Sx employing Rx channels Ci is released by a timeslot Tx. The base station 1 attempts therefore to allocate the Rx free channels Ci to a service Sy employing Rx channels Ci in the timeslot having the highest priority value Pi among those having lower priority value compared to that of the timeslot Tx. To this purpose, the base station 1 searches, if existing, a timeslot where at least a service employing Rx channels Ci is allocated, among the timeslots with priority value Pi lower than that of the timeslot Tx. This search is made through a scanning based on a variable T cyclically decreased by one unit. If said timeslot T is found, the service Sy characterised by the highest path loss amongst all the services employing Rx channels Ci in timeslot T is allocated in the timeslot Tx. In this last case, since a service having Rx channels Ci in the timeslot T has got free, the algorithm described up to now is reiterated starting from this last timeslot, which is then identified as timeslot Tx in the reiteration of the algorithm itself, that is Tx = T.

If the variable T is reset, the search can be terminated or, a service Sy employing a number of channels Ci lower than Rx newly searched among all the timeslots with a priority value Pi lower than that of the last timeslot Tx released. Said research is made through ad additional scanning based on a variable R cyclically decreased by one unit. Once this last variable is reset, the algorithm is terminated.

Other embodiments of the method according to the present invention can possibly include variants of said release algorithm, always started on the moment on which a service Sx employing Rx channels Ci is released by a timeslot Tx. For instance, instead of searching first the services Sy employing Rx channels Ci among all the timeslots having a priority value Pi lower than that of the timeslot Tx, to pass then to the search of services Sy employing a number of channels Ci lower than Rx always among all the same timeslots, it is possible to search the service Sy characterised by the maximum attenuation employing a number of channels Ci equal to or even lower than

Rx in all the timeslots having lower priority value Pi compared to that of the timeslot Tx. With this algorithm, active services can therefore be reordered according to PLx attenuation values and increasing priority Pi values, irrespective of the number of channels Ci they employ.

At each allocation and/or release of a service, the priority values Pi assigned to the timeslots Ti can be recalculated. In place of the known algorithm based on the formula

$$Pi(k) = \frac{k-1}{k} Pi(k-1) + \frac{s_i(k)}{k},$$

in another embodiment of the method according to the present invention it is possible to employ the following formula in which the past experience *Pi(k-1)* and the current situation $s_i(k)$ maintain a constant weight during the time:

$$Pi(k) = \lambda Pi(k-1) + (1-\lambda)s_i(k),$$

where λ is a memory factor included between 0 and 1, which can be freely selected according to the weight one wants to assign to the past experience or to the contingent situation. It is therefore clear that if λ tends to 0 or to 1, the priority values Pi vary in a quicker or lower way, respectively, depending on the interference and/or quality measures of channels Ci by the base station 1.

A further development of this other embodiment can consist in calculating $s_i(k)$ not on the basis of the simple statistics of the successful connections compared to total connections, but on the basis of the following formula:

$$s_i(k) = \frac{N_{free_i}(k)}{N_{max} - N_{used_i}(k)};$$

in which $N_{free\ i}(k)$ is the number of channels Ci which can be allocated with a good quality in timeslot i, N_{max} is the maximum number of channels (or codes) available per timeslot and $N_{used\ i}(k)$ is the number of channels currently already allocated in the timeslot i.

Other embodiments and/or additions of the present invention may be made by those skilled in the art without departing from the scope thereof as defined by the claims.

AMENDED CLAIMS

1. Method for the dynamic allocation of radio channels (Ci) in digital telecommunication networks with time division duplex access, the radio channels (Ci) being associated to radio signals divided into frames having a pre-determined duration and each frame is divided into a pre-determined number of timeslots (Ti) which are assigned priority values (Pi) based on interference and/or quality measures of channels (Ci), each communication service (Sx) employing a particular number (Rx) of said channels (Ci) at a time, **characterized in that** includes the following operational steps:

a) measuring the path loss (PLx) of the signal with which said communication service (Sx) has been requested;

b) allocating said number (Rx) of channels (Ci) of the communication service (Sx) in a timeslot (Tx) having a priority value (Pi) increasing with the path loss (PLx) of the signal, in such a way that the services employing said number (Rx) of channels (Ci) are allocated in timeslots (Ti) having priority values (Pi) increasing with the path loss (PLx) of the signal.

2. Method according to the previous claim, characterized in that at each request for a communication service (Sx) the services employing the same number (Rx) of channels (Ci) of the requested service (Sx) are reordered in such a way that the attenuation (PLx) increases with priority values (Pi).

3. Method according to one of the previous claims, characterized in that it includes an allocation algorithm including the following operational steps:

- first searching, starting from timeslots (Ti) with highest priority values (Pi), a timeslot (Tx) having a number of free channels (Ci) equal to the number (Rx) of channels (Ci) of the requested service (Sx);
- second searching, starting from timeslots with priority values (Pi) higher than that of the timeslot (Tx) found with the first search, a communication service (Sy) having the same number (Rx) of allocated channels (Ci);
- comparing the path loss values of the signals of the requested communication service (Sx) and of communication service (Sy) found with the second search;
- allocating, according to the result of this comparison, one of these communication services (Sx, Sy) in the timeslot (Tx) having said number (Rx) of free channels (Ci).

4. Method according to the previous claim, characterized in that said algorithm is reiterated according to the result of said comparison between the attenuation values of the signals of the requested communication service (Sx) and of the communication service (Sy) found with the second search.

5. Method according to claim 3 or 4, characterized in that it is searched, starting from timeslots with priority values (Pi) higher than that of the timeslot (Tx) found with this first search, the communication service (Sy) whose signals show the lower attenuation (PLm) among the communication services having the same number (Rx) of channels (Ci) allocated in the same timeslot (Tx).

6. Method according to one of the previous claims, characterized in that at each release of a communication service (Sx) are reordered according to increasing priority values (Pi) the services employing the same number (Rx) of channels (Ci) of the service released (Sx).

7. Method according to the previous claim, characterized in that it includes a release algorithm including the following operational steps:

- third searching, among the timeslots with priority values (Pi) lower than that of the timeslot (Tx) of the released communication service (Sx), a timeslot (T) in which at least a communication service having the same number (Rx) of channels (Ci) of the communication service released (Sx) is allocated;
- allocating in the timeslot (Tx) of the released communication service (Sx) the communication service (Sy) characterised by the highest attenuation among all the services employing Rx channels (Ci) in the timeslot (T) found with the third search.

8. Method according to the previous claim, characterized in that said third searching and allocating steps of the release algorithm are performed as in the following:

- third searching, among the timeslots with priority values (Pi) lower than that of the timeslot (Tx) of the released communication service (Sx), a timeslot (T) in which at least a communication service employing a number of channels (Ci) lower than that of the communication service released (Sx) is allocated;
- allocating in the timeslot (Tx) of the released communication service (Sx) the communication service (Sy) characterised by a higher attenuation amongst all the services employing a number of channels (Ci) lower than that of the communication service released (Sx) and which are allocated in the timeslot (T) found with the third search.

9. Method according to claim7 or 8, characterised in that said algorithm is reiterated starting from the timeslot of the last communication service released (Sy).

10. Method according to one of the previous claims, characterized in that at each allocation and/or release of a service, the priority values (Pi) assigned to the timeslots (Ti) are re-calculated on the basis of the following formula:

$$Pi(k) = \lambda Pi(k-1) + (1-\lambda)s_i(k),$$

where k is the instant at which the service is allocated or released, $s_i(k)$ is a logic function returning a number between 0 and 1 on the basis of the negative or positive result, respectively, of these requests for connection services and λ is a memory factor included between 0 and 1.

11. Method according to the previous claim, characterized in that $s_i(k)$ is defined by the following formula:

$$s_i(k) = \frac{N_{free_i}(k)}{N_{max} - N_{used_i}(k)};$$

in which $N_{free\ i}(k)$ is the number of channels Ci that can be allocated with a good quality in the timeslot i, N_{max} is the maximum number of channels available for each timeslot and $N_{used\ i}(k)$ is the number of channels presently already allocated in timeslot i.

12. System for the dynamic allocation of radio channels (Ci) in digital telecommunication networks with time division duplex access, the system including at least one base station (1) for the reception and transmission of radio signals associated to the radio channels (Ci) from/to a plurality of user equipment (2), the radio signals being divided in frames having pre-determined duration and each frame being divided into a pre-determined number of timeslots (Ti) which are assigned priority values (Pi) based on interference and/or quality measures of channels (Ci), each communication service (Sx) employing a particular number (Rx) of said channels (Ci) at a time, **characterized in that** said base station (1) includes means for the measurement of the path loss (PLx) of the signal with which said communication service (Sx) has been requested, as well as a control processor suitable to implement all the steps of the method according to one of the previous claims.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
8 February 2001 (08.02.2001)

PCT

(10) International Publication Number
WO 01/10155 A1

(51) International Patent Classification[7]: **H04Q 7/36**, H04B 7/26

(21) International Application Number: PCT/EP00/07119

(22) International Filing Date: 24 July 2000 (24.07.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
MI99A001710 30 July 1999 (30.07.1999) IT

(71) Applicant *(for all designated States except US)*: **SIEMENS INFORMATION AND COMMUNICATION NETWORKS S.P.A.** [IT/IT]; Viale Piero e Alberto Pirelli, 10, I-20126 Milano (IT).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **MARGHERITA, Fulvio** [IT/IT]; Via Giacomo Puccini, 18, I-80127 Napoli (IT). **PAROLARI, Sergio** [IT/IT]; Via Canaletto, 14, I-20133 Milano (IT).

(74) Agent: GIUSTINI, Delio; Siemens Information and Communication Networks S.p.A., Cascina Castelletto, I-20019 Settimo Milanese (IT).

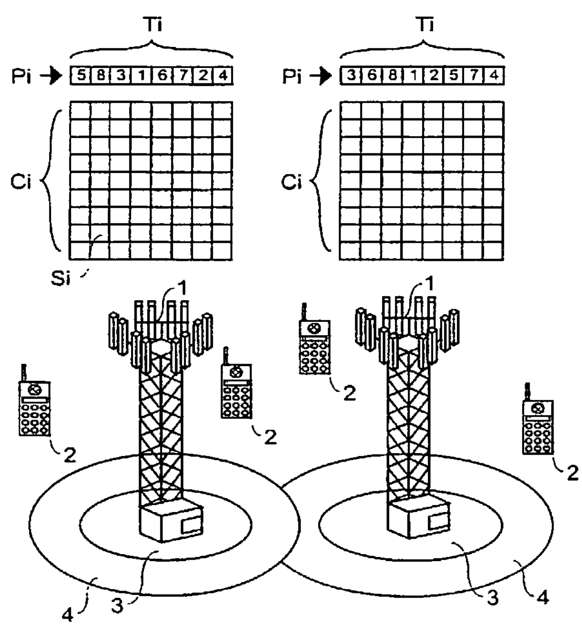
(81) Designated States *(national)*: CA, CN, JP, US.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published:
— *With international search report.*
— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD AND SYSTEM FOR DYNAMIC ALLOCATION OF RADIO CHANNELS IN DIGITAL TELECOMMUNICATION NETWORKS



(57) Abstract: Method for the dynamic allocation of radio channels (Ci) in digital telecommunication networks with time division duplex access, whose radio signals are divided into frames having pre-determined duration and each frame is subdivided into a pre-determined number of time intervals (Ti) which are assigned priority values (Pi) based on measures of channel interference and/or quality (Ci), each communication service (Sx) employing a particular number (Rx) of said channels (Ci) at a time. This method includes at least a measurement of the signal attenuation (PLx) with which said communication service (Sx) has been requested, as well as the allocation of said number (Rx) of channels (Ci) of the communication service (Sx) in a time interval (Tx) having an increasing priority value (Pi) with the attenuation (PLx) of the relevant signal, in order that the services employing said number (Rx) of channels (Ci) are allocated in time intervals (Ti) having increasing priority values (Pi) with the attenuation of the relevant signal.

WO 01/10155 A1

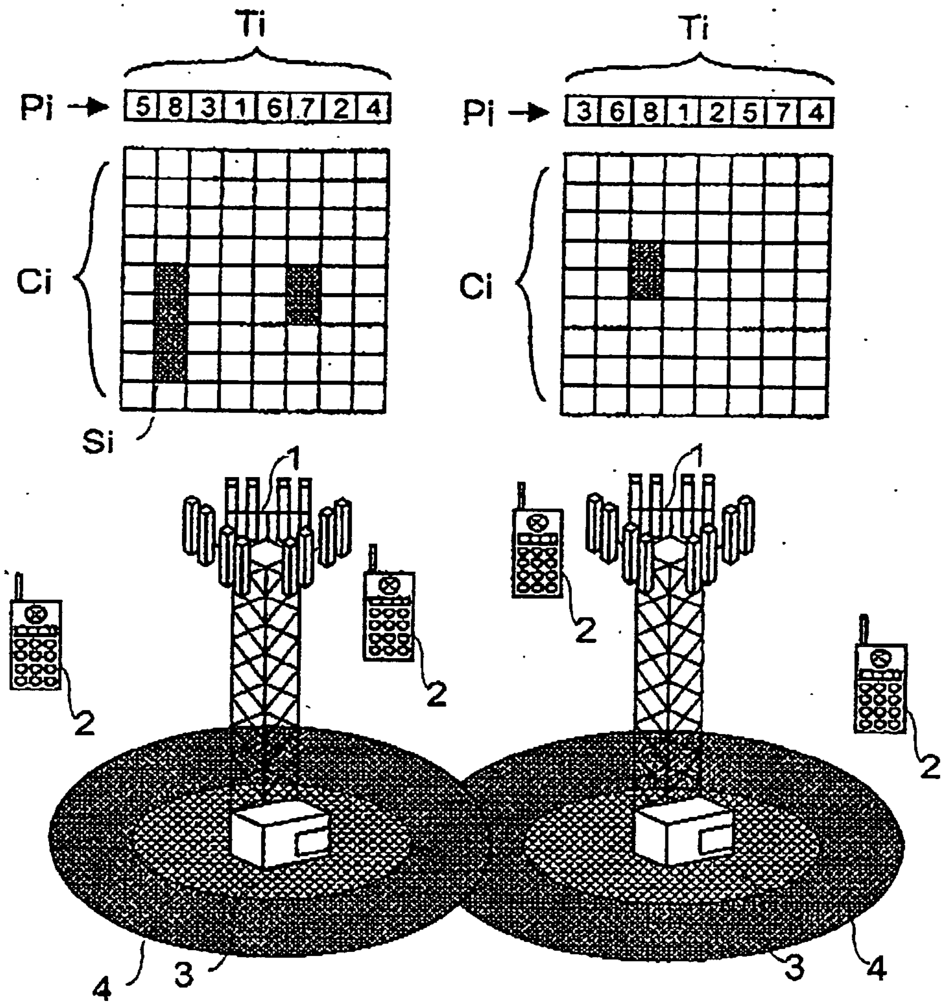


Fig.1

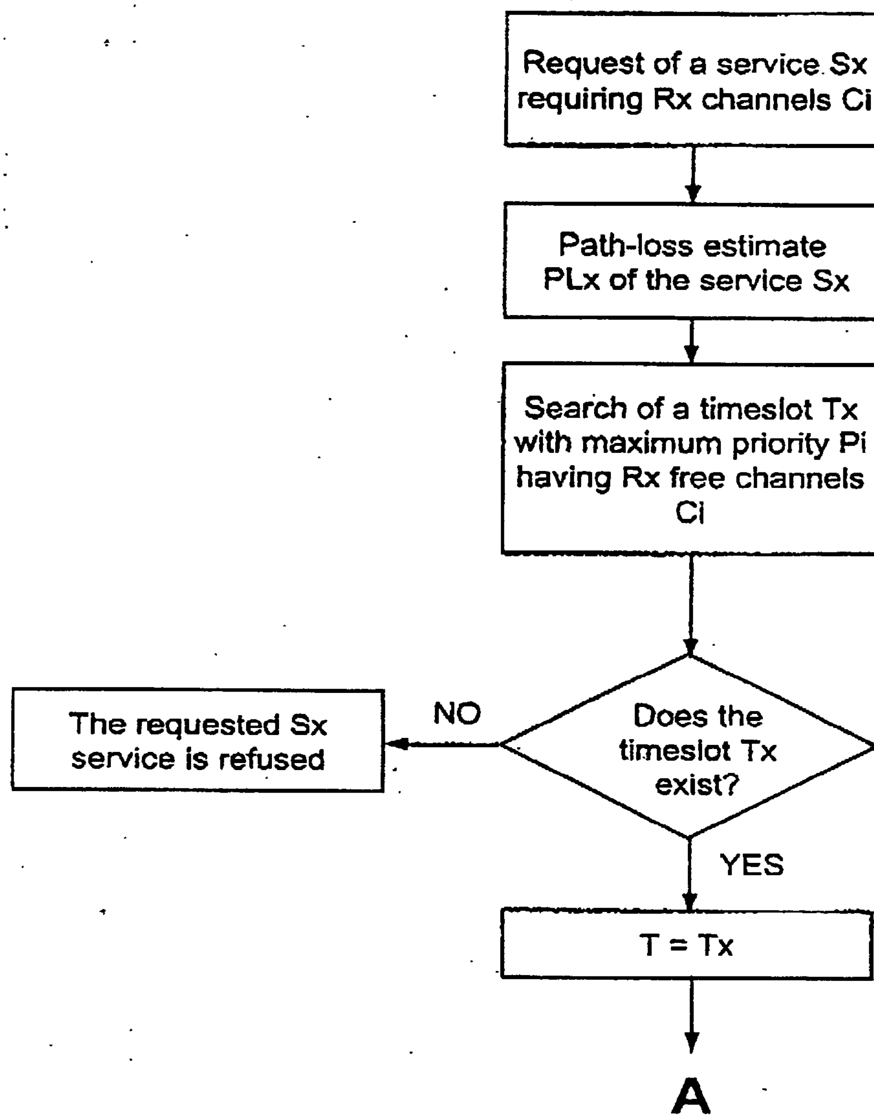

Request of a service Sx requiring Rx channels Ci
Path-loss estimate PLx of the service Sx
Search of a timeslot Tx with maximum priority Pi having Rx free channels Ci
Does the timeslot Tx exist?
NO
The requested Sx service is refused
YES
T = Tx
A

Fig.2

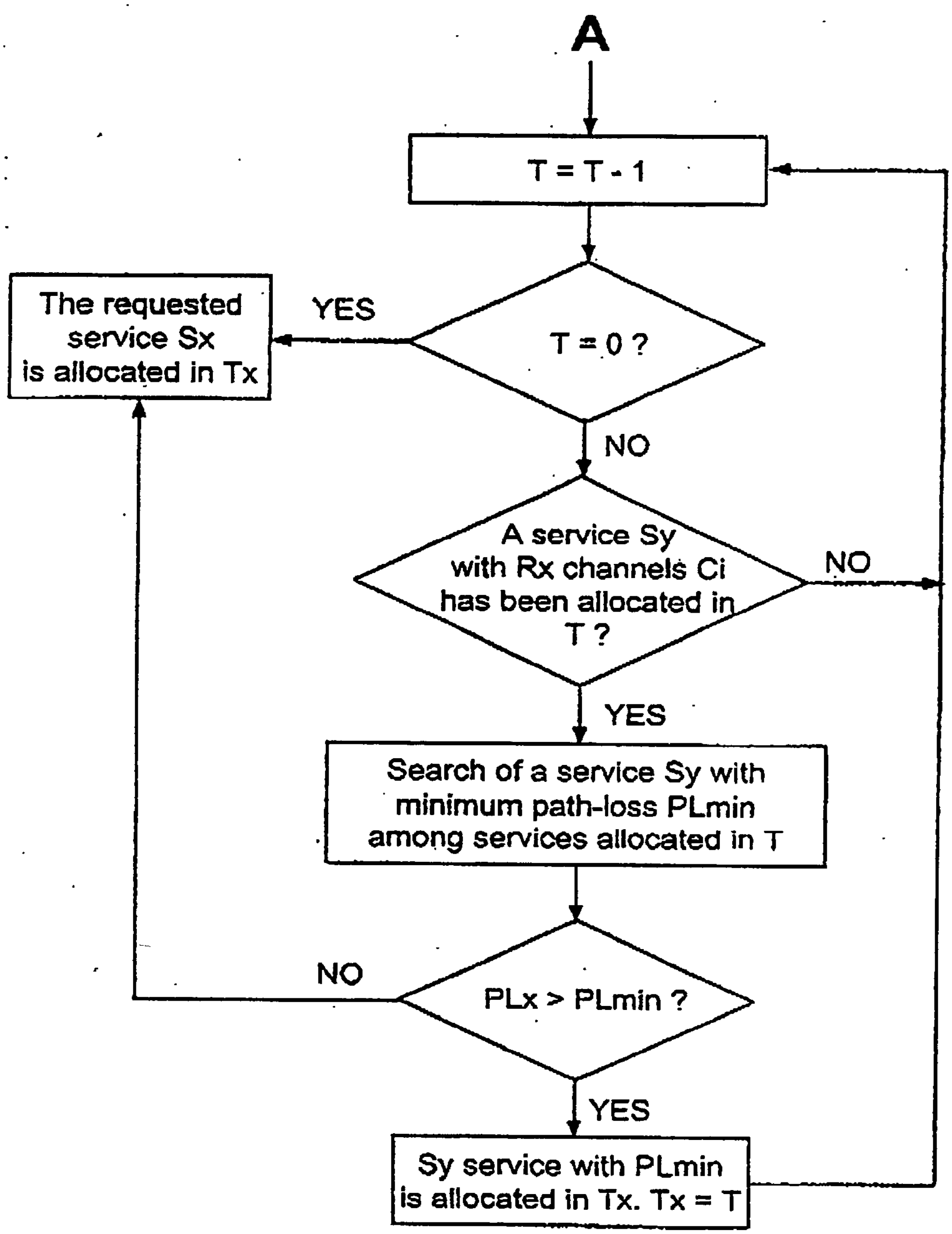


Fig.2 (continuation)

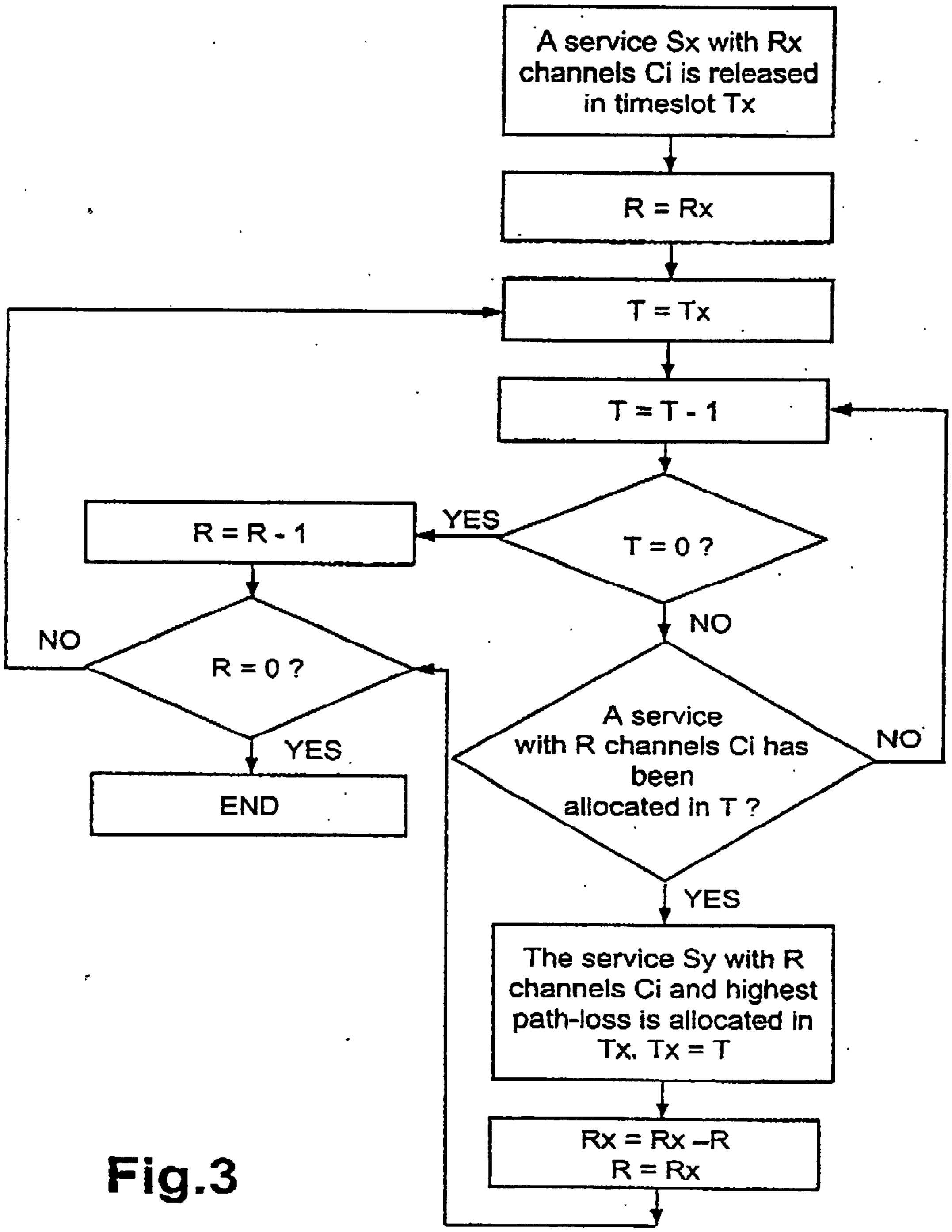

A service Sx with Rx channels Ci is released in timeslot Tx
R = Rx
T = Tx
T = T - 1
T = 0 ?
YES
NO
R = R - 1
R = 0 ?
NO
YES
END
A service with R channels Ci has been allocated in T ?
NO
YES
The service Sy with R channels Ci and highest path-loss is allocated in Tx. Tx = T
Rx = Rx –R
R = Rx

Fig.3

Attorney Docket No.

BIRCH, STEWART, KOLASCH & BIRCH, LLP
P.O. Box 747 · Falls Church, Virginia 22040-0747
Telephone: (703) 205-8000 Facsimile: (703) 205-8050

SE NOTE: YOU MUST COMPLETE THE FOLLOWING

COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT AND DESIGN APPLICATIONS

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated next to my name; that I verily believe that I am the original, first and sole inventor (if only one inventor is named below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: Method and system for dynamic allocation of radio channels in digital telecommunication systems

Insert Title:

Fill in Appropriate Information - For Use Without Specification Attached:

the specification of which is attached hereto. If not attached hereto,
the specification was filed on ______ as
United States Application Number ______;
and amended on ______ (if applicable) and/or
the specification was filed on 07/24/2000 as PCT
International Application Number PCT/EP00/07119; and was
amended under PCT Article 19 on ______ (if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I do not know and do not believe the same was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representative or assigns more than twelve months (six months for designs) prior to this application, and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns, except as follows.

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Insert Priority Information: (if appropriate)

Prior Foreign Application(s)

(Number)	(Country)	(Month/Day/Year Filed)	Priority Claimed	
ITALY	MI99A001710	07/30/1999	☒ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional applications(s) listed below.

Insert Provisional Application(s): (if any)

(Application Number)	(Filing Date)

All Foreign Applications, if any, for any Patent or Inventor's Certificate Filed More than 12 Months (6 Months for Designs) Prior to the Filing Date of This Application:

Insert Requested Information: (if appropriate)

Country	Application Number	Date of Filing (Month/Day/Year)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States and/or PCT application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States and/or PCT application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to the patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

Insert Prior U.S. Application(s): (if any)

(Application Number)	(Filing Date)	(Status - patented, pending, abandoned)

Attorney Docket No.

I hereby appoint the practitioners at CUSTOMER NO. 2292 as my attorneys or agents to prosecute this application and/or an international application based on this application and to transact all business in the United States Patent and Trademark Office connected therewith and in connection with the resulting patent based on instructions received from the entity who first sent the application papers to the practitioners, unless the inventor(s) or assignee provides said practitioners with a written notice to the contrary:

Send Correspondence to:

BIRCH, STEWART, KOLASCH & BIRCH, LLP or **CUSTOMER NO. 2292**
P.O. Box 747 Falls Church, Virginia 22040-0747
Telephone: (703) 205-8000 Facsimile: (703) 205-8050

PLEASE NOTE: YOU MUST COMPLETE THE FOLLOWING:

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of First or Sole Inventor; Insert Name of Inventor; Insert Date This Document is Signed — 1-00

GIVEN NAME/FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Fulvio MARGHERITA	Fulvio Margherita	28/1/02
Residence (City, State & Country): 80127 NAPOLI - ITALY		CITIZENSHIP: ITALIAN ITX
MAILING ADDRESS (Complete Street Address including City, State & Country): Via Giacomo Puccini, 18 - 80127 NAPOLI - Italy		

Full Name of Second Inventor, if any; see above — 2-00

GIVEN NAME/FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Sergio PAROLARI	Sergio Parolari	14/2/02
Residence (City, State & Country): 20133 MILANO - ITALY		CITIZENSHIP: ITALIAN ITX
MAILING ADDRESS (Complete Street Address including City, State & Country): Via Canaletto, 14 - 20133 Milano - Italy		

Full Name of Third Inventor, if any; see above

GIVEN NAME/FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Residence (City, State & Country)		CITIZENSHIP
MAILING ADDRESS (Complete Street Address including City, State & Country)		

Full Name of Fourth Inventor, if any; see above

GIVEN NAME/FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Residence (City, State & Country)		CITIZENSHIP
MAILING ADDRESS (Complete Street Address including City, State & Country)		

Full Name of Fifth Inventor, if any; see above

GIVEN NAME/FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Residence (City, State & Country)		CITIZENSHIP
MAILING ADDRESS (Complete Street Address including City, State & Country)		

Full Name of Sixth Inventor, if any; see above

GIVEN NAME/FAMILY NAME	INVENTOR'S SIGNATURE	DATE*
Residence (City, State & Country)		CITIZENSHIP
MAILING ADDRESS (Complete Street Address including City, State & Country)		

*DATE OF SIGNATURE

SCANNED,# 8

United States Patent & Trademark Office

Office of Initial Patent Examination -- Scanning Division

Application deficiencies found during scanning:

☐ Page(s)__________ of ______________________________ were not present for scanning.
(Document title)

☐ Page(s)__________ of ______________________________ were not present for scanning.
(Document title)

☑ ***Scanned copy is best available.*** Some pages of Application have lines.